On the other hand, the psychological investigation into our reasoning powers does not seem very interesting or convincing. Prof. Mach's treatment is genetic, and must always be open to the objection that it is not necessary in intellectual development that the growth of the individual should repeat the history of the growth of the race. Indeed, the influence exerted on our present thought by the few men of real genius is so great as to preclude at once the biological analogy. We regret to see that Prof. Mach in his treatment of time and space makes no mention of the work of Poincaré; he seems to be struggling with difficulties that have been solved already by that brilliant author. Much of the last few chapters would become superfluous if it were recognised that changes in time and space are only phenomenal changes to which we are led to attribute special importance because of their relation to other classes of mental facts which are summed up as "will" and "memory."

Any judgment of a philosophical treatise must depend on the opinions of the reader. The author's exposition is lucid, though all writings in German tend naturally to cumbrousness. It is probable that some will find in this volume valuable ideas which are new to them and suggestive illustrations of those with which they are familiar; but others will prefer Prof. Mach the mathematician to Prof. Mach the philosopher.

N. R. C.

MATHEMATICS FOR SCHOOLS.

The Winchester Arithmetic. By C. Godfrey and G. M. Bell. Pp. ix+199. (Cambridge: University Press, 1905.) Price 3*s.*

A Text-book of Algebra. Part i. By A. E. Layng. Pp. viii+176. (London: Blackie and Son, Ltd., 1905.) Price 2*s.* 6*d.*

An Introduction to Algebra. By R. C. Bridgett, F.C.S. Pp. 95. (London: Blackie and Son, Ltd., 1905.) Price 1*s.*

Elementary Modern Geometry. Part i. By H. G. Willis. Pp. viii+236. (Oxford: Clarendon Press, 1905.) Price 2*s.*

Tables and Constants to Four Figures. By William Hall. Pp. ix+60. (Cambridge: University Press, 1905.) Price 3*s.* net.

MESSRS. GODFREY AND BELL'S excellent arithmetic consists mainly of sets of exercises, many of them oral, very carefully graded, and charmingly fresh and varied. A large number of the exercises refer to interesting current events and subjects, and thus incidentally impart quite a fund of general and useful information to the young reader. The metric system is in constant use along with the more important British measures, and by its aid decimals are taken before vulgar fractions. Commercial arithmetic is ably dealt with, but is not allowed an undue monopoly. The needs of the worker in the laboratory are not overlooked, for the course includes approximations, the mensuration of simple plane and solid figures, logarithms, with a chapter on graphs, while symbols and formulæ are introduced from the first, "exhibiting algebra as shorthand arithmetic." The student is not allowed much chance of working unintelligently by rule, and is everywhere encouraged to think for himself, for the rules and processes are left to be given orally by the teacher, who can obtain a special interleaved copy of the book containing model exercises and all the answers. This admirable text-book will rank high amongst its fellows, and it would be difficult to find a school arithmetic more worthy of general use.

In part i. of the algebra by Mr. Layng, the subject is developed in very easy stages, generalising from arithmetic, and is carried up to the solution of simple quadratic equations. In choice of matter the author gives preference to parts which have an immediate practical application, as being specially suitable for young beginners. Graphs are very freely used. The applications include the mensuration of plane geometrical figures.

The algebra by Mr. Bridgett proceeds on somewhat similar lines to that just noticed, but the explanations are briefer, and only simple equations are dealt with. The applications include proportion, profit and loss, simple interest, discount, mixtures, work, averages, areas and volumes. Answers to the exercises are given.

Mr. Willis's volume is the first part of what promises to be an important text-book of elementary pure geometry, representing the present position of the science. The first chapter is experimental and practical, with the object of making the student familiar with the things he is about to study. Chapter ii. deals with first principles. Here the definitions, axioms, and methods of geometrical deduction are fully discussed, and fundamental propositions relating to lines, angles, and triangles are established. In addition to the usual axioms, the author gives axioms of continuity, displacement, and rotation. The next chapter is a short one, containing problems and graphs. The last chapter treats of parallels. Playfair's axiom is introduced as an alternative to the rotation axiom, and reasons are given for not adopting Euclid's criterion of parallelism. Notions about limits, infinity, loci, &c., are introduced and used in the propositions, so that the student acquires these comparatively early in his course. The present part is intended to cover the ground required for ordinary pass examinations, and the forthcoming part, it is hoped, will be suitable for honours. Sets of exercises are given at short intervals, the answers to those which are numerical being collected at the end. The book is one that should be known to all teachers, and is likely to be used by many.

The four-figure tables by Mr. Hall comprise square roots, squares and reciprocals, the ordinary logarithms and anti-logarithms of numbers, and the usual logarithmic and natural functions of angles. In addition, there is a useful three-figure traverse table, occupying eighteen pages, giving the products of all numbers from 10 to 99 into the sines and cosines of angles from 1° to 89°, with intervals of 1°. There are also tables of natural and logarithmic haversines, or half-

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versines, these valuable tables being thus now readily accessible. The author also includes short tables of refraction and dip, sufficient for beginners in navigational astronomy. There is a brief description of the use of the tables, and a five-page collection of useful numbers and physical constants. The tables are carefully compiled and skilfully arranged, and seem thoroughly serviceable and trustworthy.

STATICS IN THE MIDDLE AGES.

Les Origines de la Statique. By P. Duhem. Vol. i. Pp. iv+360. (Paris: A. Hermann, 1905.) Price 10 francs.

THIS book is sure to arouse the interest of all who study the history of natural science, and it may cause a certain amount of controversy owing to the nature of its conclusions; but even if some of these have to be modified, enough will remain to shed a new light on the progress of mechanics in the middle ages. The main result, and this is established beyond all reasonable doubt, is that the mechanics of the fifteenth and sixteenth centuries must not be regarded as a sudden achievement, but as a development of ideas current in the thirteenth and fourteenth centuries, many of which were unscrupulously reproduced without acknowledgment.

Who, then, are these predecessors to whom even Galileo and Descartes probably owed more than they ever confessed? In the first place, Jordanus Nemorarius, or more properly Jordanus de Nemore. Nothing is known of his personal history; Moritz Cantor is inclined to identify him with Jordanus Saxo, but Prof. Duhem conjectures that he may have been an Italian, Giordano of Nemi, and this is plausible enough to deserve further investigation. Manuscript evidence tends to show that his works were composed in the twelfth century at latest. Prof. Duhem's researches lead him to the following conclusions about Jordanus and his mediæval successors. Jordanus wrote a treatise of which the proper title seems to have been "Elementa Jordani super demonstrationem ponderis"; of this there is a thirteenth-century fragment and a fifteenth-century text apparently complete. He had studied Aristotle, and the "De ponderoso et levi" attributed to Euclid; but his treatise seems to be original, and not a translation from the Greek. He discusses the equilibrium of the lever by a method which is essentially that of virtual velocities, and even seems to be on the brink of discovering the infinitesimal calculus.

Jordanus's treatise became classical; it was associated with the "De canonio" (attributed to Euclid), and transformed in various ways by commentators without improvement. But there is another work, attributed to Jordanus, "De ratione ponderis," which is of still greater interest and importance. It contains the notion of the moment of a force, the correct theory of a bent lever, and the solution of the statical problem of two weights connected by a string and resting on two different inclined planes. Prof. Duhem is probably right in saying that this was not written by Jordanus, but by an unknown successor whom he calls the "precursor of Leonardo da Vinci." The main argument is that some errors of the "Elementa" are here corrected. It is not impossible that Jordanus wrote it *after* his other treatise, tacitly amending his previous mistakes; however this may be, the author was familiar with Jordanus's "Elementa," and his work is contained in a thirteenth-century MS.

The next great figure to appear on the scene is that of Leonardo da Vinci. It is not very easy to decide how much of theoretical statics Leonardo found out for himself; he had a clear notion of moments, but, on the other hand, his ideas about the composition of forces were vague and incorrect. He does not appear to have added anything essential to what was already known in the thirteenth century; but it is likely enough that his manuscripts suggested valuable ideas to some of those into whose hands they fell.

The later chapters of the book deal with the facts relating to Galileo, Stevinus, Roberval, and Descartes; this period is better known, and it is needless to go into details here. The main point is that, however much we owe to sixteenth-century mathematicians, it is wrong for us to regard them as the founders of an absolutely novel theory of statics; and although this conclusion may somewhat dim our mental picture of the glories of the Renascence, it will deepen our piety towards those *obscuri viri* who cultivated science and learning when they were most in danger of extinction. It is noteworthy that in other directions, such as the history of painting, the same kind of verdict on the Renascence appears to be forming.

The teaching of mechanics to average students is a very difficult and often ungrateful task. One is often tempted to lose one's temper, and unfairly blame the pupil for his stupidity. It is a wholesome corrective to think of the slow progress of the theory and of the extraordinary mistakes made in connection with it by men of unusual ability. Thus it took years of controversy to establish the fact that a uniform bar, supported at its centre of mass, is in neutral equilibrium; and it was long taken for granted that a two-pound weight fell to the ground twice as fast as a one-pound weight.

G. B. M.

SPECTROSCOPY.

Spectroscopy. By E. C. C. Baly. Pp. xi+568; illustrated. (London: Longmans, Green and Co., 1905.) Price 10*s.* 6*d.*

THIS important addition to the well-known series of text-books edited by Sir William Ramsay will be welcomed by all who are interested in the progress of spectroscopy, and especially by students of physics and chemistry who may desire to engage in spectroscopic study and research. The book, indeed, fills a gap in spectroscopic literature which has long existed, providing in a moderate compass a comprehensive guide to modern methods of investigation, the theory of the instruments employed, and the principal results which have been arrived at in the application of spectroscopic methods to chemistry and physics. In each of these departments the explanations are gener

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